

Rochester Institute of Technology

**RIT Scholar Works**

---

Theses

---

5-30-1986

## The design and construction of furniture for mass production

Kevin Stark

Follow this and additional works at: <https://scholarworks.rit.edu/theses>

---

### Recommended Citation

Stark, Kevin, "The design and construction of furniture for mass production" (1986). Thesis. Rochester Institute of Technology. Accessed from

This Thesis is brought to you for free and open access by RIT Scholar Works. It has been accepted for inclusion in Theses by an authorized administrator of RIT Scholar Works. For more information, please contact [ritscholarworks@rit.edu](mailto:ritscholarworks@rit.edu).

ROCHESTER INSTITUTE OF TECHNOLOGY

A Thesis Submitted to the Faculty of  
The College of Fine and Applied Arts  
in Candidacy for the Degree of

MASTER OF FINE ARTS

The Design and Construction of Furniture for Mass Production

By

Kevin J. Stark

May, 1986

APPROVALS

Adviser: Mr. William Keyser/ William Keyser

Date: 5/30/86

Associate Adviser: Mr. Douglas Sigler/

Date: Douglas Sigler

Associate Adviser: Mr. Craig McArt/ Craig McArt

Date: 5/30/86

Special Assistant to the  
Dean for Graduate Affairs: Mr. Phillip Bornarth/ Philip Bornarth

Date: 6/6/86

Dean, College of Fine  
& Applied Arts: Dr. Robert H. Johnston/

Date: Robert H. Johnston Ph.D.

I, Kevin J. Stark, hereby grant permission to the  
Wallace Memorial Library of RIT, to reproduce my thesis in whole or  
in part. Any reproduction will not be for commercial use or profit.

Date: 5 30 86

## CONTENTS

Thesis Proposal.....	i
CHAPTER I - Introduction	1
CHAPTER II - An Investigation Into The Design and Construction Process	
Side Chair.....	2
Executive Desk.....	12
Conference Table.....	18
Shelving Unit.....	25
CHAPTER III - A Perspective On Techniques Used In Industrial Furniture Design	
Wood.....	33
Metals.....	37
Plastics.....	41
CHAPTER IV - Conclusion.....	47
CHAPTER V - Footnotes.....	49
CHAPTER VI - Bibliography.....	50

## ILLUSTRATIONS

	<u>Page</u>
I. Side Chair.....	10-11
II. Executive Desk.....	16-17
III. Conference Table .....	23-24
IV. Shelving Unit.....	31-32

The purpose of this thesis is to design and construct pieces of furniture that could be produced by a furniture manufacturer. Included within this thesis will be a documentation of my research into contemporary industrial furniture design, an explanation of the process I will use to design the pieces and a discussion of the techniques I will use to fabricate these pieces.

This thesis will be divided into two parts. The first part consists of a discussion of the furniture I have built for this thesis. The discussion includes a review of the process I used to design each piece and an explanation of the techniques used.

The second part of this thesis deals with a historical perspective of processes used in contemporary furniture. This part is divided into three areas: wood, metal, and plastics.

## **II. AN INVESTIGATION INTO THE DESIGN AND CONSTRUCTION PROCESS**



## Side Chair

The first piece of furniture that I chose to design for my thesis was a chair. Chair design, according to the designer Niels Diffrient, is the acid test for designers. When one considers the structural, functional, and aesthetic demands placed on a chair in today's society, it is easy to understand Diffrient's position. Whatever consensus of opinion there might be on chair design as the test for designers ends at this point, for there seems to be as many different philosophies of chair design as there are chair designers.

One of the most interesting controversies surrounding the design of chairs is the varying degree of importance placed by designers on form or function. At one end of the spectrum we find Nicos Zographos, an internationally noted architectural, interior and furniture designer. Zographos sees the challenge of designing a chair in terms of form first and as a sitting device second. He feels chair design is always the result of a number of compromises such as budgets, available technology, materials, distribution, as well as other limitations. However, the biggest problem is created by the fact that a chair is supposed to accommodate the human figure in the unnatural position of sitting. Zographos goes on to state that although there have been numerous studies done on human comfort, these studies can

only serve as guidelines because of their lack of attention to the non-average male or female body. There are no two people with exactly the same bodies or that sit in the exact same way.(1)

On the other side of the fence sit designers such as Niels Diffrient. Diffrient believes that comfort is an integral part of chair design. He is aware of the infinite variations of the human body and aims his designs at accommodating 95% of the population. Comfort, to Diffrient, is not totally attainable for all people in all chairs. However, he states that designers who downplay or ignore comfort altogether, dealing with form alone, can only produce an incomplete product.(2)

My personal feeling on this subject seems to be in constant change. My training as a sculptor has made me aware of the potential visual energy of three dimensional form. I am and have been interested in creating objects that work well "in the round" and not just from one or two views. My involvement with sculpture has helped me see the tremendous potential of three dimensional form as a means of expression and communication. From a strictly sculptural point of view, I would have sided with the advocates of the function follows form belief. However, since I have been involved in designing furniture, I have come to believe that the parameters of furniture design need not lead one to watered down

or eclectic ideas. I see these parameters as a starting point, that grow and develop in the design process and not as rigid inflexible limitations. The sculptor, as well as the furniture designer has parameters to deal with (though not nearly as many).

I feel it is naive to take an overly sculptural approach to chair design as Nikos Zographos has. To create a seating devise with such a great emphasis on the visual in my opinion does not confront the intended purpose of the devise. However, it is a well known fact that there is an over abundance of awkward and ugly chairs in the world today, and I see no reason to add to that number a design of my own. If aesthetics are left out, a computer could be fed human engineering data and design a suitably functional chair. The problem seems to be to use ergonomic research as a foundation upon which to build the visual elements.

The chair problem assigned by Mr. William Keyser dealt with the design and construction of an upright wooden chair that should be comfortable for short duration use. This chair should be highly portable and adaptable enough to be used for dining, writing, or talking. One of the primary concerns I had during the design process of this chair was to become aware of the demands of mass production on chair design and put this information to use.

My search for a solution to this problem began with a

series of perspective sketches. I used perspective drawings because I felt it was important to envision the chair in three dimensions. This approach led to some interesting but impractical results. The chair designs tended to be overly complicated and intricate and therefore not suitable for mass production. At this point, Mr. Douglas Sigler, suggested sketching a side elevation of the chair. He recommended thinking of the side elevation as an extruded frame. His suggestions proved to be invaluable. My designs quickly became simpler which allowed me to give more attention to proportion and detail. After deciding on the sketch which seemed to have the greatest potential, I drew this design in perspective; I then began to incorporate the side elevation, with the top and front views. This sketch was then evaluated by the criteria which were established at the outset of the design. Having satisfied myself that I was proceeding in the right direction, the next step was to make a full scale cardboard model.

The cardboard model was necessary so that I could refine the proportion and details which were sure to change as the design developed from two dimensions to three dimensions. My first reaction to the completed full scale model was that I had created a cage for the occupant to sit in. Although I felt the design on paper worked well visually, in reality the combination of the front legs with the back created a claustro-



phobic feeling for the sitter. To overcome this problem, I decided to decrease the leg and back height. This not only gave the chair a more open and comfortable look but also made it possible to incorporate arm rests into the design. The model also gave me the opportunity to explore different seat and back shapes in scale.

After these decisions had been made, I then referred to the ergonomic data collected by Niels Diffrient (3). In addition, I also introduced the scaling measurements of three of the chairs that I had found comfortable during my visit to Designer's Saturday in New York City. These chairs were Robert DeFuccio's Triangle Chair, Robert Pettit's Pettit Ply Chair, and Warren Snodgrass's Continuum Chair.

Using this information as a starting point, I then began to test different seating proportions and angles. I found the process of creating different seats and backs, and then actually sitting in them to be the most reliable indicator of chair comfort. Seating research and previously designed chairs may serve as adequate starting points, but in the end, seat of the pants experimentation is the most valuable method of evaluation.

When the testing was completed, my next step was full scale orthographic drawings. At this stage, I was confronted with integrating the ergonomic data with this prototype design and making decisions on what joinery would be used.

The section of the back of the chair which the sitters back would come in contact with, was to be an arc with a 24" radius. In the interests of aesthetics, the proportions and size of the back of the chair were compromised. The compromises consisted of lowering the back, bringing it closer to the seat, and decreasing the vertical angle of the back, which made the chair much more upright in nature.

The major joinery decision to be made in this design was how to join the front legs with the back. After considering other possibilities, I decided to use the finger joint. This joint was used because of its visual interest and ease of manufacture. A minor design change that I realized would have to be made if this piece were to be mass produced, was the refinement of where the back and front legs are joined. In the original design the shoulders of the back leg needed to be cut on a curve, but with minor alterations this problem could be easily overcome. The front and back stretchers on this chair design were handled with standard mortise and tenon joinery.

When the full scale drawings had been completed, for all intents and purposes the actual design process ended. At this point, it was a matter of taking the pieces of the puzzle and then putting them together. However, before proceeding to the next piece, there are some observations I would like to relate.

Historically, furniture has always served as an indicator of social and economic ranking. The king's throne is the prime example. This thought is as predominant today as it was in the past. While critiquing my chair, Mrs. Phyllis M. Collough, Vice President for Marketing for Thonet Industries, felt that my chair would be marketed as a "front of the desk" chair. When asked to explain further, she went on to say that there is a specific order in which chairs are marketed. The biggest and most expensive (luxurious) chair in the office would be located behind the desk. The next most prestigious chair would be located at the side of the executive desk, followed by the chair positioned in front of the desk, and finally by the chairs which would be placed in other areas in the room.

During the 1950's, office furniture design was dominated by a half dozen large furniture companies producing very similar looking chairs. As the need for office work mushroomed, so did the marketing strategies of these companies and their new competitors. One of these strategies was the practice of identifying chair models by job classifications such as secretarial, clerical, management and executive. The secretary's chair soon became stereotyped as small and armless, while the executive's chair in almost all cases were large and with arms. This created a potential problem for the manufacturers because a good secretary's chair could



cost more to make than the boss's chair and yet had to sell for less. This practice of identifying chairs by position served to enhance the chair as a status symbol and also caused the chairs to be priced and purchased according to corporate rank.

The awareness of the implications of status created by chairs has led the American Telephone and Telegraph Company to formally codify by position, exactly what types of chair and how many chairs each executive receives in his office. This configuration has apparently alleviated the inter-office in-fighting for furniture at AT & T.

There are many factors to be considered when designing a chair for industry. I would recommend that a designer have an awareness of how and where his product would fit into an office setting before the design process began. Another recommendation would be for a designer to become familiar with the philosophies and techniques used by different furniture companies. From the wide range of reactions I received on my completed chair from companies such as J. G. Furniture, Knoll International and Thonet Industries, it became evident that each firm had strong ideological biases and were better equipped to handle some materials and techniques than others. It is the designer's job to become aware of this knowledge.







## DESK

The next piece of furniture designed for my thesis was a desk. The desk was intentionally designed to not coordinate with the chair. I felt I would learn more by designing unrelated pieces and using different techniques than I would by designing a desk, chair and credenza line. The design process began with perspective and front view sketches. My early attempts were concerned with having the design develop according to functional and manufacturing concerns. Each sketch was evaluated by these two criteria. In my effort to design a highly affordable and efficient desk, the designs I was creating at this point were either very eclectic or very uninteresting. I found it extremely difficult to depart from the slab over two cubes approach. It seemed that whether I liked it or not, I always returned to this format. This method of investigation turned up nothing.

A fresh start was in order so I decided to temporarily disregard any of the functional or manufacturing requirements that I was previously using as my standards of evaluation. I was intent on designing a desk that wasn't a knock-off of an existing model or based on some easily repeated technical feat. I wanted this desk to be a unique entity that displayed its own personality. I was determined to either create an original design and adapt the functional requirements to it or not design it at all. This attitude proved

much more productive in this process of design. I felt much less restricted and free to experiment. I submitted five drawings to Mr. Craig McArt for review and after some discussion, we both decided that one drawing in particular offered the greatest potential. I had previously taken measurements of desks and also used furniture catalogs as references for proper desk dimensions. My next step was to begin quarter scale orthographic drawings.

As the drawings proceeded and decisions about materials and techniques were being resolved, it became apparent that this prototype was going to be extremely expensive and time consuming to make. Rather than just completing the chair and the desk in my thesis year, I opted for creating a quarter scale model of the desk, a conference table, and a shelving unit in addition to the chair.

It takes a great deal of sensitivity to work successfully with the number of details on an executive desk. My approach to detailing has consistently been to first create the overall form and then go back and refine the details. In industrial furniture design, the subtle manipulation of proportions and great amount of attention given to details, such as a reveal, can visually make or break the design.

One of the strongest elements that I felt my final design had to offer was a continuity or flow caused by the legs wrapping around the ends of the table. As the drawings

progressed I became aware of the complicated joinery necessary to make the legs in wood. This joinery would impede the rhythm of the legs. Wood was rejected for the legs for this reason. Tubular steel was the logical choice as a solution for aesthetic as well as production reasons. Mr. Fred Jentch, Jentch Steel Fabrication Company, was extremely helpful in offering information about bending tubular steel. After some negotiation with dimensions, we arrived at thicknesses and radii that would cause a minimal amount of distortion.

The next aspect of the desk design that I felt was worthy of attention was that the drawer carcasses were cantilevered. This cantilevering of the drawers gave the desk a light and airy look and also made it easy to incorporate them with the modesty panel. The modesty panel I devised for this desk left a 4" space between the desk top and the panel and also left an 8" space between the bottom of the panel and the floor. The range of reactions I received about this detail from people associated with the furniture design industry gave me an interesting insight into design. Mr. Dave Woods, Design Director for J. G. Furniture, Quakertown, Pa, thought that the panel was effective visually and functionally because it screened so much from the view of someone approaching or sitting in front of the desk. In contrast to this opinion, Barbara Saving, Design Associate, Knoll



International, N.Y., felt that the modesty panel as presented, would need some redesigning. Her feeling was that the function of the modesty panel was to visually and physically establish boundary between the front and back of the desk. This boundary would create a private space under the desk top where shoes, boxes, or bags could be stored and vision would be obstructed from the desk front. Ms. Saving felt that by leaving an opening at the top and bottom of the panel, I was defeating its intended purpose. This diversity of opinion from professionals has been alluded to earlier and has been included to emphasize the importance of a free lance designer knowing his product and market and having as many design details resolved as possible before he/she approaches a company.

I then built a quarter scale model of the desk specifically for that reason. This model was made from red oak and 5/8" steel rod which was heated and bent. The model's purpose was to create in a smaller scale a visual impression of the desk design. It gave me the opportunity to experiment with different proportions and relationships and also resolve any lingering detail problems.







## Conference Table

Prior to starting my next design, a list of parameters was drawn. This list helped clarify what I was attempting to accomplish and also defined what functional and aesthetic considerations I would use as a foundation for this design process. The parameters were as follows:

PROBLEM: 1) to design a line of tables, including a conference, coffee and end tables; 2) the design should be adaptable both aesthetically and structurally to the different sizes and proportions of the tables; 3) to construct the conference table.

LENGTH: The length of the conference table will be determined by two factors. The first being that each person seated at the table will be allotted a minimum of 29" of lateral space in front of the table. This dimension will leave an ample amount of space for the intended functions of the table and also enough room to accommodate the chair widths that would be used with this table.

WIDTH: The factors that will affect the design of the width of the table are: 1) surface area of the table in front of each person; 2) knee and foot room. Each sitter will be allotted a minimum of 20" of table space and a minimum of 20" of unobstructed foot room at the floor and 10" of unobstructed knee room at knee height.

HEIGHT: The height of the conference table will be 29-1/2".

EDGE TREATMENT: The edge will be handled in a manner that is consistent with the overall design of the table as well as comfortable and as physically pleasing as possible.

SURFACE TREATMENT: The surface will be designed so that it could be manufactured in a number of materials such as plastic laminate, veneer, glass, or leather.

The early sketches for the conference table were concerned with exploring different structural systems of bases to give the top support. Three systems of bases that I became interested in were a) using a center column with projecting feet; b) intersecting planes and c) the traditional four legs at the corners of the table. As my drawings progressed, the use of a column offered some pleasing variations of design although my sketches tended to be overly influenced by previous ideas and added nothing original to this approach. Through the use of planes as a base, I was unable to arrive at a design that was interesting and did not obstruct the leg room listed in the parameters. After I had decided to pursue a four legged table, it was not long before I arrived at a drawing that I thought worthy of more attention.

This design appealed to me for a number of reasons. I thought it could easily be adapted to a line of tables. This line could be produced very simply and yet work well together. In addition, this table design was very simple and

straight forward and yet included enough subtleties to maintain the viewers interest. Another aspect of this design that I was pleased with, was that as a viewer walked around the table it's appearance would change. These factors in combination with the potential for details in the legs were the reasons for my pursuing this design.

My original intent in regards to the legs was that they should be either quarter or half sections of a pipe. I experimented with fabricating the leg sections in molded plywood and acrylic sheets that were heated and formed, but due to additional time and labor demands these techniques were rejected. I was then presented with the challenge of finding a pipe that was commercially available, light in weight, durable, and relatively inexpensive. For one or more of the above reasons the following materials were unacceptable: acrylic tubing, cardboard sonotube, (similar to the tubes that are found in carpet stores), steel and aluminum. Of this group aluminum pipe offered the most potential for mass production, but for a one off prototype the expense was exorbitant. The material I selected for the legs was polyvinyl chloride pipe (PVC).

The next question to be answered was, "Is a stretcher system needed, visually or structurally?" After doing more drawings and some discussion with my committee members I decided that visually the design did not need the addition of

a framework below the table top. The simplicity of the design was one of the factors that was most appealing to me and I intended if possible, to see this feeling through. Structural considerations, however, were another matter. Legs located at the corners of a table are placed under a considerable amount of stress from different directions. The problem then became a matter of connecting the legs to the table top in the strongest and most appealing manner.

After some less than successful experiments fabricating sheets of PVC into a bracket support, 12 gauge steel was used. The steel bracket was then attached to a PVC table leg and also to a piece of wood, which simulated the table top. This full size mock up withstood an excessive amount of force and as a result of this testing it was decided that the brackets would be fabricated from 12 gauge steel. A detailed full scale drawing was then done of the corner.

The treatment of the top was the next problem to be resolved. So that the weight of the table top could be kept to a minimum I decided to use a high impact styrene core between two one-quarter inch sheets of walnut veneered plywood. In the corner areas, where the brackets were to be attached, uniform laminate plywood was inserted. The brackets could then be screwed into the bottom of the table top and the back of the table legs.

As mentioned earlier the legs offered the potential for



a wide range of design solutions. The PVC pipe could be painted, veneered, sandblasted, left in its original state or altered in innumerable ways. I was concerned with how the top of the leg and the table top would interact visually.

To help integrate the legs with the top I decided to veneer the interior of the legs. After a series of tests, a veneer with cloth backing was chosen because of its flexibility. The edges and exterior of the legs were painted with a black polyurethane paint. The black paint worked well in contrast with the walnut veneer.

The table line, in retrospect, was consistent with the parameters established at the beginning of the design process.





## Shelving Unit

The final piece that I decided to make for my thesis was a shelving unit. I decided to ask Mark Sfirri, Design Director at Hardwood House to act as an advisor on this project. I thought his advice as a designer within the contract furniture industry would be very helpful and informative. At our first meeting we discussed the following list of parameters from which my design was to originate.

PROBLEM: To design a shelving unit that would be used for magazine and book storage, paper filing, general shelving uses, and possibly clothing storage.

MARKET: This unit would be designed for office use with the possibility of residential applications.

MATERIALS: Use a veneered plywood that is currently in style. Darker species such as cherry, walnut or mahogany would fall into this category.

PRODUCTION TECHNIQUES: This product will be designed so that it can be quickly and easily fabricated and assembled. There would be a minimum of joints.

OTHER CONSIDERATIONS: The unit should be a modular system that would be knock-down, and would have adjustable shelves.

These parameters gave me a starting point for designing the shelving unit, but were general enough to not be overly restrictive.



An element I intended to pursue in the shelving unit was a uniqueness in design. After receiving a great amount of feedback on my portfolio from designers at companies such as Knoll International, Thonet Industries and JG Furniture Systems, one comment in particular seemed to pop up. The consensus of opinion was that my purely sculptural work (done prior to my enrolling at RIT) had a life and personality that my furniture designs lacked. They felt there was an element in the sculptures which made those pieces unique to me and that that element was missing in my designs for furniture. I began the shelving unit drawings with the intent to incorporate this uniqueness into the design.

My first drawings were concerned with approaching the problem of supporting a shelving system from many different angles. With the help of Mr. Doug Sigler, I designed a variety of units that served as room dividers that were supported by projecting feet or were hung from the ceiling. Another set of drawings dealt with a wall hung unit. The simplicity of the wall hung system seemed to offer some exciting possibilities. However, Mr. Sfirri strongly recommended against any system other than using the floor as a base. He felt that in order for the shelving unit to be successful it must be easy to assemble and install in any city in the country. Mr. Sfirri did not speak highly of the talents of the men hired to install contract furniture. Even

a task as simple as lining up wall mounted brackets would more often than not lead to crooked shelves. Because of this, he recommended designing the unit to be as "idiot-proof" as possible. By this he meant keeping the operations of assembly as few and as simple as possible.

The problem had evolved into creating a freestanding shelving unit. I experimented with three different methods of support. These methods were a frame system, a planer system (2 vertical planes), and a modular box system. Of the three, modular units offered the most potential. My original drawings dealt with a system that would have different size modules that could be stacked in any number of ways. The spatial relationships formed by these modules were interesting and, because they could be arranged in so many different formations, offered a great amount of flexibility.

After discussing this system with Mr. Sfirri it became apparent that I still could maintain the visual interest and flexibility of the system by using modules of the same size. This would simplify the production process and therefore reduce its cost.

My next step was to investigate the dimensions of the shelving unit so that it would fulfill its intended functions. After researching recommended shelf heights and depths and observing similar units produced by different manufacturers I decided on making each module 28" h x

35-1/2" w x 14" d. These dimensions left ample room for magazine storage as well as paper filing. In an office situation I envisioned three units vertically which would be a total height of 7'. Although time and monetary considerations allowed me to make only three units, (hinged door, paper divider and straight shelves) I saw the line eventually including such options as filing units, magazine racks, sliding door units, drawer units, etc.

At this point I began to realize that my goal of uniqueness was being compromised. Due to financial and practical necessities my shelving unit design did not directly resemble any other unit I had seen, but on the other hand lacked that personality I was striving for. I thought that my treatment of the details could help remedy the situation. By increasing the thickness of the tops of the modules I hoped to increase visual interest by juxtaposing thick and thin. Through the use of full size cardboard mock-ups I arrived at a 1-1/4" thickness for the tops and shelves as well as the sides. I felt that this did add some interest to the piece.

Another detail that needed to be worked out was how to align the modules as they stacked upon one another. I considered many different possibilities. My eventual choice for this detail was suggested to me by Mr. Douglas Sigler. His recommendation was to route a 1/4" groove around the edges of the side panels. A plastic or metal spline could



then be inserted into the groove. This spline could not only act as an alignment mechanism but also offer many visual design possibilities as well.

The treatment of the back panel of the modules presented a number of questions that needed to be answered. My first reaction was to use 1/4" cherry plywood that would be inserted into a groove cut into the side panels. However, this idea was rejected because of the lack of rigidity in the plywood. Another potential problem was the alignment of the back panel with the end panel.

There are many advantages to making a piece of furniture knock-down. Not only can the piece be shipped in unassembled pieces, but it also allows the buyer the option of taking it apart and moving it. In this case there would be a great saving of space if the modules did knock down. I began searching for a fastener that was inexpensive, easy to install, and unobjectionable visually. After some experimentation, I decided upon using a BLUM assembly fitting. These fittings cost approximately 10 cents each, required only two drilled holes, and although they appeared as a half circle under the shelves when the modules were assembled, they did not hinder the overall design. The installation of these fittings gave me a shelving unit that was extremely flexible. It could be arranged in many different combinations and also be easily shipped, assembled and knocked

down.

My original goal of injecting a life into this unit I feel was unsuccessful. Although this piece passed the majority of criteria which I had established at the outset, I feel in the final evaluation it lacked in personality. It is hard to say where my intent failed. It could have been my overall approach to the problem, or possibly the parameters I worked within.





III. A PERSPECTIVE ON TECHNIQUES USED IN  
INDUSTRIAL FURNITURE DESIGN



This chapter of the thesis will be concerned with the history of contemporary furniture design. It will be a discussion of my research into the processes and people who have shaped contract furniture.

#### WOOD

Although many attempts had been made to bend solid wood sections, it wasn't until Michael Thonet's experiments in the 1840's and 50's that this process became a reality. Thonet discovered that by clamping a thin flexible strip of steel along one side of a piece of steamed European beechwood and by bending this piece into a shaped metal mold, chair parts could be quickly and efficiently produced. This technique led to designs that eliminated virtually all of the complex joinery in chair construction. Elements could be lapped over one another and joined with screws. The first widely accepted mass produced chair, chair #14, consisted of only six parts which could be easily produced, shipped and assembled. This chair was first marketed in 1859 and by 1900 over forty million had been sold.(4) The technique of steam-bending solid wood was significant not only because of its powerful influence on twentieth century furniture design, but also because of its impact on the mass production of furniture.

The process of bending thin laminates of wood with glue inserted between the layers to form curved shapes is not a

new one. Michael Thonet had actually used this technique in chair construction prior to his bending solid wood. However, two Scandinavian designers in the twentieth century were to have an even greater effect; Alvar Aalto, the Finnish architect, and Bruno Mathsson, a Swedish designer. Aalto's ability to integrate machine technology with personal humanistic expression is unsurpassed. Aalto felt that the human body should come in contact only with organic material. Aalto spent many years doing extensive experiments in the bending of laminates. He is given credit for designing the first cantilevered chair in wood.

Mathsson like Aalto, was interested in the textural qualities of wood and also in its plastic and structural possibilities. He designed chairs which were based on detailed anatomical studies. This led him to conclude that the ideal material for his chairs would be a malleable substance such as laminated bentwood. Through their experimentation and designs, Aalto and Mathsson, established themselves as pioneers in modern bent laminate furniture.

In the 1960's two American designers named Donald Pettit and Bill Stephens added to the bent laminate vocabulary by designing chairs of their own. Actually, Pettit and Stephens had worked together on the research and development of the "Pettit Ply" chair while they were both associated with Knoll International. In the Stephens chair, the rear stile, side

seat rail and front leg are made of a single curving piece of bentwood. This method departs radically in concept from traditional chairmaking and creates a chair with an unusually fluid and graceful line.(5)

Molding plywood into curved surfaces was another important development in wooden furniture construction in the twentieth century. Alvar Aalto was also an innovator in this area. His stackable chair of 1930, made for "The Minimal Apartment" exhibition in Helsinki, was noteworthy due to its use of a molded plywood seat.

Aalto's most famous chair, Armchair 41, also has a seat of bent plywood, molded on two different forms. An incredible amount of strength is accumulated in the plywood as it is bent and in this case although the seat-back is extremely flexible, it is virtually unbreakable.

The next significant advance in plywood technology was developed by Charles Eames and Eero Saarinen in the "Organic Design In Home Furnishings" exhibition in 1941. They were awarded two first prizes, one for a molded plywood chair. The bending of plywood in two directions, introduced at this show by Eames and Saarinen proved to be more difficult to mass produce than at first thought. After six years of experimentation Eames, working with his wife Ray, was able to perfect the complex curve problem for mass production. Eames's meticulous attention to detail and thorough knowledge



of the latest technology has made him a dominant figure among contemporary designers.

Traditional wooden joinery has been used for centuries, going as far back as the Egyptians. The challenge of the twentieth century brought new demands on joinery techniques. The "Scandinavian Modern" movement played an important role in the development of traditional woodworking joinery into mass production techniques. Interestingly enough, this movement began not in the furniture manufacturing plants of Scandinavia, but in small cabinet shops. Kaare Klint, the director of the furniture design program at the Copenhagen Art Academy was very influential in this movement. His goal was to create timeless and eminently practical furniture. Klint regarded a piece of furniture as an implement which should fulfill its purpose in the same way a workman's tool does. Scandinavian furniture has over the years developed a reputation for simplicity, utility and impeccably finished traditional materials. The individual quality of Scandinavian furniture exemplified by Hans Wegner's Round Chair, has been the result of the way it is made with industrial prefabrication and hand finish.(7)

## Metals

At the turn of the last century, the only metal that was used in furniture was the springs in the upholstery. In the 1920's however, that trend would begin to change as bent tubular steel began to be used in furniture design. As the story goes Marcel Breuer was struck by the idea of using chrome plated steel tubing while admiring the handles of his bicylce. His "Wassily" chair, named after his friend the painter Wassily Kandinsky was the first to use tubular steel. Breuer had these comments about metals, " In the course of my work on series manufacture and standardization I had come across polished metal surfaces-reflecting, fine lines in space - as new components of our home furnishings. In these shimmering, curving lines I saw not only symbols of modern technology but technology itself".(8)

Credit for the first cantilevered chair is given to the Dutch architect, Mart Stam. His first prototype, out of gas pipes and fittings, was later improved upon by inserting solid bars into the curved sections of the tubular frame for reinforcement. It was Mies Van der Rohe, in his MR. Chair, however, who was the first to exploit the spring like quality of the steel tubes in cantilevered form. The early tubular steel designs by these men borrowed liberally from the techniques and designs of Michael Thonet. Mies was also influential in the development of using bent steel bar stock



as a furniture component. This development led to his famous Brno chair, and to the Barcelona chair (the widely accepted symbol of modern furniture).

LeCorbusier (the universally accepted pen name of Charles Edouard Jenneret) also designed tubular steel furniture. Although he used the unpretentious bentwood armchair of Thonet in different buildings he designed (so much so that his name became synonymous with that chair) he eventually felt the need to design his own furniture. He, along with Pierre Jeanneret and Charlette Perriand, developed a number of designs that use "modern materials" in a way that generates excellent utility and an ideological preference for expression related to industrial production, as seen in his Basculant chair and Chaise Loungue of 1928.(9)

In the 50 years that have passed since these developments countless imitations have been produced. In more recent years, the tubular steel designs of Paol Kjaerholm stand out as unique. Although, undeniably his work owes a great deal to Breuer, Mies, and LeCorbusier, his ingenious use of materials and ability to simplify elements while retaining their functional advantages has separated him from the multitude of designers that have knocked off the classic designs in tubular steel.

Harry Bertoia and Charles Eames were key figures in the use of metal wires in chair construction. Bertoia, a

sculptor by trade, was approached by Hans and Florence Knoll and asked "to do what you feel like." Eames also developed a line of chairs for Herman Miller using a similar lattice structure. Eames and Bertolia collaborated on the development of wire furniture and were influenced by the new developments in rapid spot welding techniques. It wasn't until the mid-60's that wire was used as the principle material in furniture design by Warren Platner. Platner's technique differs from Bertolia's and Eames in that he used continuous vertical wires that were tied together like sheaves of wheat rather than meshed. In 1961 he began welding metal wires to metal rings to obtain "a small scale detail related to overall form. This was the important thing, like people who are forms with details: hair, eyebrows, noses, etc. I wanted the furniture to be all one form, not just a furniture of tops and bottoms, which is the usual thing".(10)

Although others had used steel rod in chair construction such as Charles Eames in his CM chair, no one had used this material more ingeniously than David Rowland in his 40/4 stacking chair. The chair name derives from the fact that it can be piled 40 high in a stack that is only four feet overall. By using a very high-tensile steel rod (7/16" in diameter) with a formed sheet metal seat and back, he created a comfortable and distinctly unique chair. His design is

important not only because of its use of modern technology, but also because of its influence on subsequent furniture designs.

Aluminum has been used in furniture for many years. Marcel Breuer participated in a competition for aluminum furniture in 1922. Hans Coray, the Swiss designer, is given credit for designing the first all aluminum chair in 1939. The seat and back of his Landi Stuhl chair was formed in a single piece from sheetmetal stamped by a large drop press, and then punched with holes. Both seat and leg frame were worked and finished in a soft condition and then tempered by heat to the required hardness. Charles Eames had used aluminum as early as 1956 in the base he designed for his famous Lounge Chair. His largest contribution to design in aluminum was his "Aluminum Group" manufactured since 1958 by Herman Miller, Inc. This group used a cast aluminum supporting frame in addition to aluminum arms and base. Others like the American designer Richard Schultz in his Leisure collection of 1966 have continued to use aluminum in their designs.



## PLASTICS

Nowhere has the effect of modern technology been more evident in the twentieth century than in plastics. The rate of development of different plastics has been and is today truly astounding. It would be inconceivable to list all the advances in plastic technology, so as I have done for the sections on wood and metals, I will review only the most important innovations.

Although molded fiberglass had been used in airplane construction for many years, it wasn't until 1949 that it was used in furniture. Charles Eames' DAR chair had originally been designed to be fabricated from sheets of metal. However, when the costs of tooling in metal proved to be too expensive, Eames began experimenting with fiberglass-reinforced polyester, which was then used in production. This chair had a large impact on the furniture industry due to the fact that it could be mass produced so economically. Eames' meticulous attention to detail and use of newly developed technology has truly made him a pioneer in contemporary furniture design.

Molded fiberglass was also used by Eames' former protégé, Eero Saarinen. The tulip pedestal chair shell relates visually to Eames' DAR chair and they both were derived from the winning design in the "Organic Design in Home Furnishings" competition. Of his pedestal furniture,

the designer himself said, "The undercarriage of chairs and tables in a typical interior makes an ugly, confusing, unrestful world. I wanted to clear up the slum of legs. I wanted to make the chair all one thing again. All the great furniture of the past from Tutankhamun's chair to Thomas Chippendale's have always been a structural total. With our excitement over plastic and plywood shells, we grew away from this structural total. As now manufactured, the pedestal furniture is half-plastic, half-metal. I look forward to the day when the plastic industry has advanced to the point where the chair will be one material as designed."(13)

After Saarinen's and Eames' successful designs in fiberglass, other designers started to expand upon the potential of this plastic medium. Arne Jacobsen in his "Swan chair" and Eero Aarnio in his Pastilli chair illustrate just a couple of ways this material could be used. The development of molded fiberglass into chair design was significant not only because of the ramification of mass production it suggested, but also because of its influence on preceding advances in plastic technology and its potential to create exciting and innovative forms.

Injection molding is a technique in which plastic material is heated until soft, then forced into a closed mold where it cools in the shape of the mold. The mold opens and the part is forced out by ejection pins. Molds can be very



costly, but the experience of production makes this process desirable when large quantities of an object are required. This technique began being used in furniture in the 1960's.(14) Joe Columbo, an Italian designer, is given credit for designing the first all-plastic chair to be made by injection molding.

The first one-piece mass produced chair was manufactured in injection molded plastic. It was designed in 1960 by Verner Panton. The Panton stacking chair takes full advantage of advances in plastic and mold forming technology. Few designers have achieved such a logical shape in terms of comfort and strength of structure. The uniqueness of this design may be attributed to Panton's design philosophy reflected by the following quote, "I try to forget existing examples of furniture even though they may be good and concern myself above all with the material. The result then rarely has four legs, not because I do not wish to make such a chair, but because the processing of materials like wire or polyester calls for new shapes."(15)

Robin Day, the British furniture designer had this to say about his contribution to contemporary chair design, "There already existed excellent shell chairs made in glass fibre reinforced plastic, which is comparatively expensive and rigid. The invention of polypropylene seemed to me to offer exciting possibilities for the development of a new

chair. Its low cost, great strength, and suitability for injection molding made it ideal for a mass produced one piece back and seat." Day's polyprop chair of 1963 was the result of his interest in polypropylene. It was followed two years later by the Albinson chair by Don Albinson which had a seat and back of molded polypropylene.

The development of foam and fabric technique in the last thirty years has truly been astounding. Upholstery materials have changed from webbing, hessian, steel springs, hair and cotton liners to latex foam and polyester foam. The use of rubber webbing and diaphragms have added another new dimension. Pierre Paulin's Chair 582 best exemplifies some of these innovations. Knitted fabrics have enabled chairs containing compound curves to be covered much more cleanly. Because of their very good stretch and return properties they are also used for the making of removable chair covers. Foams can be molded into an endless variety of organic or geometric forms. The technological advancements in upholstery techniques have revolutionized chair design. If the past is any indication, there is sure to be many more developments in this area in the near future.

Within the last few years a new technique has been developed that will undoubtedly be a sign of things to come. This technique is based on the foaming of liquid urethane in a mold. A surface skin develops at the surface of the mold

in which foaming takes place at the right conditions of heat and pressure. It is the new knowledge of how to control variables that now makes it possible to produce a molded part soft, semi-soft, or fairly stiff inside. The surface is a smooth, tough, leathery skin which becomes the actual upholstery cover for the cushion within.

The foam and skin are fused together to form a durable and "self-healing" surface. A dent or bruise tends to vanish in a short time and if cut with a knife the wound does not actually heal but squeezes together usually invisibly and resists any further tearing or ripping. This process is used by Tom Janicz on his Sofdesk and by Atelier International on their Leonardo office chairs.

On a national scale, I project substantial changes in manufacturing methods in the next five years. The American furniture industry is ripe to be negatively affected by imports as the American automobile industry has.

Imports have already made a significant impact on residential furniture sales and I feel in time, contract manufacturers will also begin to feel the pinch.

I feel that plastics will be the area in which most of the growth and change will occur. This is due to the rate of technological advances in plastics. As new plastics are introduced, the potential for different applications become endless. Developments in metals will continue but not at the

rate and will not have the impact of plastics.

The fabrication of wood furniture is being revolutionized by numerically controlled (NC) machines. Panel saws, routers, boring machines and practically any other wood-working machine are available with (NC) capability. The hypothetical extension of (NC) equipment, in addition to advances such as computer aided design (CAD), robotics, and bar coding, is the humanless factory where parts are made and moved only by machines. I don't think this is 100 percent feasible; however, this is the direction that contract furniture will pursue.

#### **IV. CONCLUSION**



Approximately five years have passed since my thesis show and the creation of the remainder of this thesis. In that time I have worked as a Product Engineer at Hardwood House Corporation in Rochester, New York and as Director of Product Development at Metropolitan Furniture Corporation in South San Francisco, California.

The parameters used for my thesis projects were somewhat realistic. In retrospect, however, much more time should have been devoted towards developing costs for these products. The creation of a Bill of Material and a Bill of Labor (in consultation with a costing engineer at a furniture manufacturer) would have been very informative. The pieces I selected to make were excellent, however.

Two projects come to mind that would have provided a wealth of information about contract furniture. The first is a fully upholstered chair line. This would involve an investigation into different fabrics, sewing and cutting techniques, upholstery methods and frame construction. The second is a modular or airport-type seating group. This group would be designed in a material other than wood and would explore public seating requirements and the concept of modular furniture.

The design process I used on this thesis was to look upon each project as an individual entity. Furniture manufacturers tend to have a much broader perspective. While

I was concentrating on a desk, most manufacturers would be interested in offering a desk line consisting of a desk, credenza, executive return, secretarial return, table desk, and reception desk. The same concept would hold true for chairs and tables. I believe much more attention should have been given to this broader perspective.

The research and learning that took place during my thesis work has served as a solid foundation for my career. The portfolio I have developed, based on my thesis projects, has brought me in contact with the leading designers and manufacturers in the contract industry. All things considered, I feel my thesis effort is focused and successful.

**V. FOOTNOTES**

1. Barbara Prete, Chair, New York, N.Y., Thomas Y. Crowell, 1978, p. 39.
2. Ibid., p. 76.
3. Diffrient N., Tilley A., Bardagjy J., Humanscale 1/2/3, M.I.T. Press, 1976.
4. Clement Meadmore, The Modern Chair, New York, N.Y., Van Nostrand Reinhold Company., 1979, p. 13.
5. Patricia E. Kane, 300 Years of American Seating Furniture, New York, N.Y., New York Graphic Society., 1972, p. 342.
6. Karl Mang, History of Modern Furniture, New York, N.Y., Harry N. Abrams Inc., 1979, p. 202.
7. Ibid, p. 241.
8. Gerd Hajte, Marcel Breuer 1921-1962, Stuttgart, West Germany, Verlag, 1962, p. 25.
9. Karl Mang, History of Modern Furniture, New York, N.Y., Harry N. Abrams Inc., 1979, p. 79.
10. Progressive Architecture, XLVII, July 1966, p. 166.
11. Clement Meadmore, The Modern Chair, New York, N.Y., Van Nostrand Reinhold Company, 1979, p. 113.
12. Ibid., p. 158
13. Aline Saarinen, ed., Eero Saarinen On His Work, New Haven and London. Faber Publishing Company, 1962, p. 68.
14. John Pile, Modern Furniture, New York, N.Y., Wiley-Interscience, 1979, p. 45.
15. Clement Meadmore, The Modern Chair, New York, N.Y., Van Nostrand Reinhold Company., 1979, p. 131.

## **VI. BIBLIOGRAPHY**



1. Caplan, Ralph. The Design of Herman Miller. New York, N.Y.: Whitney, 1976.
2. Charlish, Anne. The History of Furniture. New York, N.Y.: William Morrow and Company Inc., 1976.
3. Drexler, Arthur. Charles Eames, Furniture. New York, N.Y.: The Museum of Modern Art, 1973.
4. Garnet, Phillippe. Twentieth Century Furniture. New York, N.Y.: Van Nostrand Reinhold Company, 1980.
5. Hiort, Esbjorn. Modern Danish Furniture. New York, N.Y.: Architectural Book Publishing Co., Inc., 1978.
6. Lucie-Smith, Edward. Furniture: A Concise History. New York and Toronto: Oxford University Press, 1979.
7. Turabian, Kate. Manual For Writers Of Term Papers, Theses, and Dissertations. Chicago, Ill.; The University of Chicago Press, 1973.